

# Four levels of communication, error, and recovery in ACT-R

Mike Matessa

Alion Science & Technology

# Example: Talk only

A:

says "I'll be right there"

B: says "OK"

(15 second pause)

B:

says "These two over here"

# Talk + direction

B:

gazes at A

A: gazes at B

says "I'll be right there"

B: says "OK"

(15 second pause)

A:

gazes at items

B: points at items

says "These two over here"

# Talk + direction + placement

A: stands far behind counter

B: stands at counter

places items on counter

gazes at A

A: gazes at B

says "I'll be right there"

B: says "OK"

(15 second pause)

A: stands just behind counter

gazes at items

B: points at items

says "These two over here"

A: picks up items

# ACT-R bot example

A: stands far behind counter  
B: stands at counter  
    places items on counter  
    gazes at A  
A: gazes at B  
    says "I'll be right there"  
B: says "OK"  
    (15 second pause)  
A: stands just behind counter  
    gazes at items  
B: points at items  
    says "These two over here"  
A: picks up items

A: stands away from path  
B: stands on path  
    gazes at A  
A: gazes at B  
    says "I'll be right there"  
B: says "OK"  
    (15 second pause)  
A: stands on path  
    gazes at B  
B: points at direction  
    says "This way"  
    moves in direction  
A: follows in same direction

# Moving ACT-R out of the desktop

- ACT-R bot in a complex environment
- Communication is more than just talking
  - Attention direction
  - Object placement
- Communication has internal & external parts
  - Internal levels of processing
  - External feedback from partner for all levels
- Understanding communication allows error prediction and error recovery

# Typical ACT-R paradigm: Instruction following

- Memorize instructions
- Observe stimulus
- Retrieve memory of relevant instruction
- Execute response

# ACT-R levels of processing

## ACT-R level

1. Attention
2. Identification
3. Retrieval
4. Action

# ACT-R levels of processing

ACT-R level	Module request
1. Attention	Visual location
2. Identification	Visual object
3. Retrieval	Declarative chunk
4. Action	Motor action

# ACT-R levels of processing

ACT-R level	Module request	Example
1. Attention	Visual location	movement loc.
2. Identification	Visual object	moving guide
3. Retrieval	Declarative chunk	instr. to follow
4. Action	Motor action	move wheels

# Levels of processing comparison

## ACT-R level

1. Attention
2. Identification
3. Retrieval
4. Action

## Clark (1996) level

1. Attention
2. Identification
3. Understanding
4. Negotiation

# Clark levels of processing

Clark level	Sender	Receiver
1. Attention	Execute	Attend
2. Identification	Present	Identify
3. Understanding	Signal	Recognize
4. Negotiation	Propose	Consider

# Clark levels of processing

Clark level	Sender	Receiver
1. Attention	Execute	Attend
2. Identification	Present	Identify
3. Understanding	Signal	Recognize
4. Negotiation	Propose	Consider

Evidence of completion:

Sender needs evidence from Receiver in order to complete level

Downward evidence:

Evidence of higher number is evidence of all lower

# Clark levels of processing

Clark level	Example: “I’ll be right there”
1. Attention	Attend to voice
2. Identification	Identify English expression
3. Understanding	Recognize meaning: delay
4. Negotiation	Consider accepting delay

# “I’ll be right there” errors

## Clark level

1. Attention
2. Identification
3. Understanding
4. Negotiation

## Possible error

- Can’t hear at all
- “Have a white chair”
- Right there = 5 sec
- Can’t wait

# ACT-R errors

ACT-R level	Possible error
1. Attention	No visual location returned
2. Identification	No visual object returned
3. Retrieval	No chunk returned
4. Action	Motor module error

# ACT-R error notification

ACT-R level	Possible error notification to partner
1. Attention	“I can’t find what I’m looking for”
2. Identification	“I don’t know what that is”
3. Retrieval	“I forget what I’m supposed to do”
4. Action	“I can’t do that”

Evidence of completion:

Sender needs evidence from Receiver in order to complete level

Downward evidence:

Evidence of higher number is evidence of all lower

# ACT-R error notification

ACT-R level	Possible error notification to partner
1. Attention	Hand above eyes
2. Identification	Squint
3. Retrieval	Scratch head
4. Action	Shake head no

Evidence of completion:

Sender needs evidence from Receiver in order to complete level

Downward evidence:

Evidence of higher number is evidence of all lower

# ACT-R recovery

ACT-R level	Possible recovery action by partner
1. Attention	Make sure in range of sensor
2. Identification	Adjust orientation for easier ID
3. Retrieval	Prompt bot with instruction
4. Action	Change environment to allow action

# Sender representation

```
=goal>
  isa communicate
  project follow-me

(follow-me
  isa project
  proposition follow-schema)

(follow-schema
  isa proposition
  agent partner
  signal my-moving)

(my-moving
  isa signal
  object self
  behavior moving)

(moving
  isa behavior
  modality visual
  feature movement)

(p recover-attention
  =goal>
  isa recover
  level attention
  agent =a
  object =o
  modality =m
  feature =f

==>
  =goal>
  isa put-in-range
  bot =a
  modality =m
  object =o
  feature =f)
```

# Conclusions

- Putting ACT-R in complex environments requires a richer representation of communication than just passing symbols
- Levels of processing in ACT-R can be used as a rich representation
- Levels can be used to predict communication errors
- Levels can be used as feedback to partner to recover from errors

# Other uses for the four levels

- Understanding task complexity
  - Attention: number of distractors in environment
  - Identification: number of object categories
  - Retrieval: number of task instructions
  - Action: number of obstacles to action